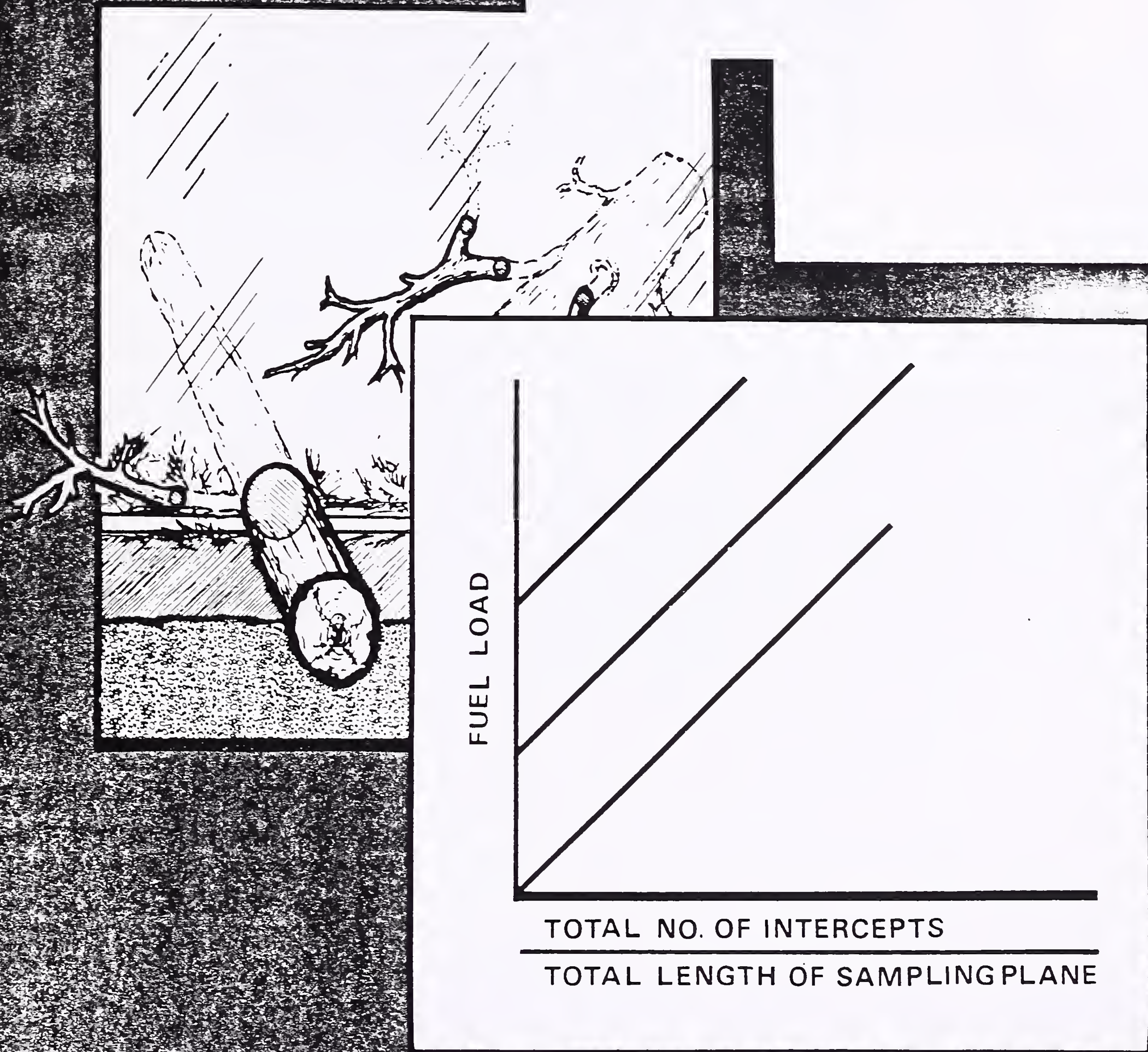
GRAPHIC AIDS FOR FIELD CALCULATION OF DEAD, DOWN FOREST FUELS

Hal E. Anderson



USDA Forest Service
General Technical Report INT-45
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

THE AUTHOR

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CONTENTS

RESEARCH SUMMARY

Increased field activities in fuel inventory have emphasized the need for methods to rapidly interpret data collected with the planar intersect sampling technique. Fuel load calculations by size class are being used as input to fire and fuel management, residue utilization, and land management planning. Rapid conversion of the data to numbers usable in the field can be accomplished with these graphic aids that complement but do not replace automatic data processing capabilities.

The graphic aids allow fuel load calculations by size class for quick field assessment. They allow adjustments for variations in slope and specific gravity of the woody material. Any greater degree of resolution should be accomplished through data processing facilities.

PLANAR INTERSECT SAMPLING

In *Handbook for Inventorying Downed Woody Material* Brown (1974) tells how to determine the quantity of fallen fuel by means of planar intersect sampling. These procedures have been used in fire management planning, timber stand inventories, and in residue utilization studies. When large areas are sampled, large amounts of data result, which makes computer processing desirable for computing fuel loads. Computer processing of data is available through the Fort Collins Computer Center Univac 1100/40 or the Lawrence-Berkeley Laboratory's CDC 7600 using the program DFINV.

Managers lack easy-to-use computational aids for quickly determining fuel loads in the field; therefore, it is difficult to compare the appearance of a stand when sampled with the determined fuel load. Also, for small amounts of data it is faster to calculate loadings by hand. In 1975, as fuel inventory activities increased in the West, graphic aids were developed in response to field requests for assistance. This paper provides graphic aids to facilitate calculating fuel loads from planar intersect sampling.

Information for calculating loading in Brown's (1974) *Handbook for Inventorying Downed Woody Material* has been consolidated into two graphs. These graphs use fuel inventory data to determine the fuel load in tons per acre for each size class of fuel: <0.25 inch (0.6 cm); 0.25 to 1.0 inch (2.5 cm); 1.0 to 3.0 inches (7.6 cm); and 3+ inches sound and dead. As a result of favorable field response to use of the graphs, forms were prepared for use in the Intermountain Region (Region 4).

This paper presents the graphs used in the Intermountain Region, (fig. 1 and 2) with the addition of corrections for slope and fuel density (specific gravity). Assumptions, use of the graphs, specific site corrections, and mean diameter effects are discussed to aid the user in improving determinations of fuel load.

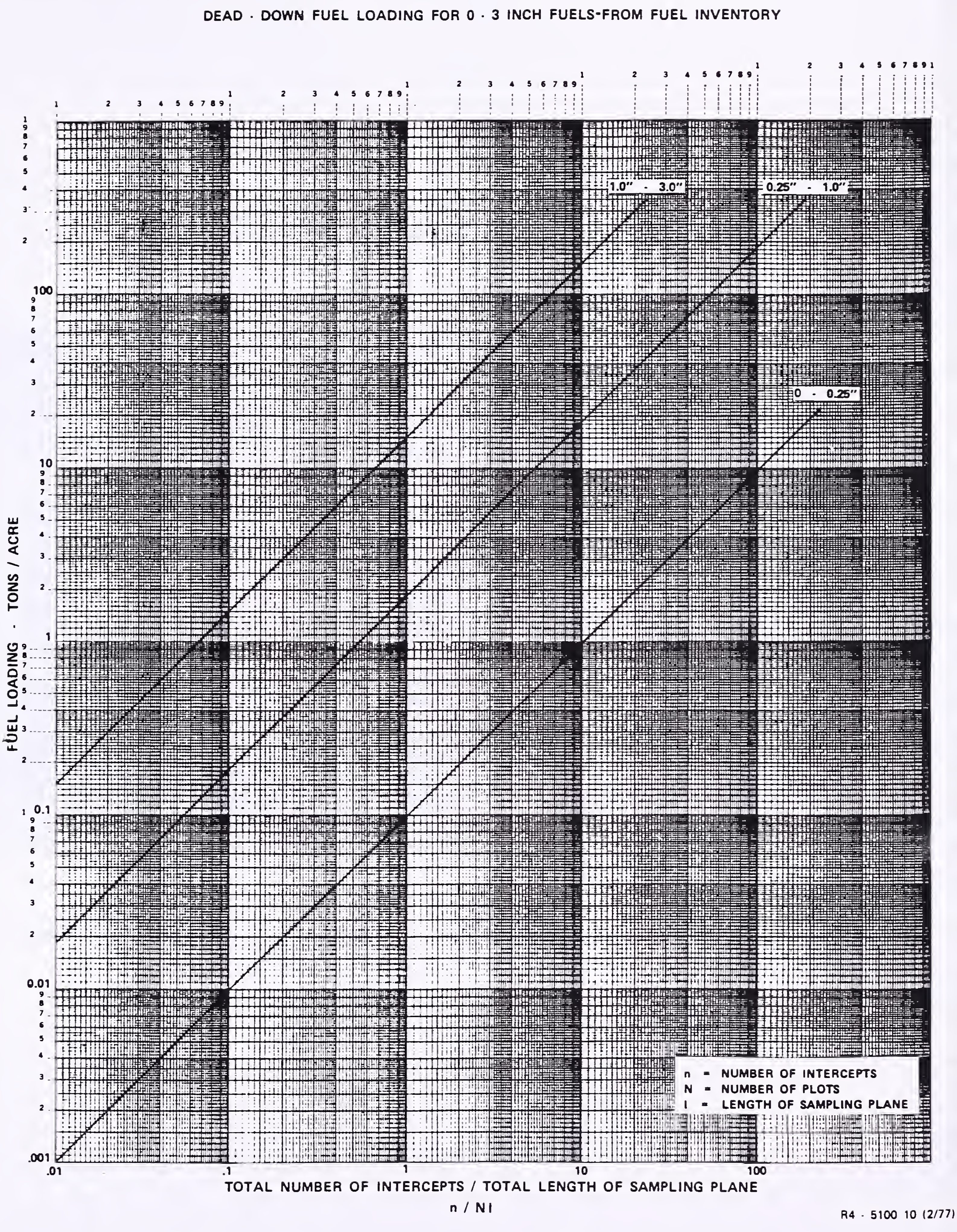


Figure 1.—Dead-down fuel load by size class from number of intercepts and transect length.

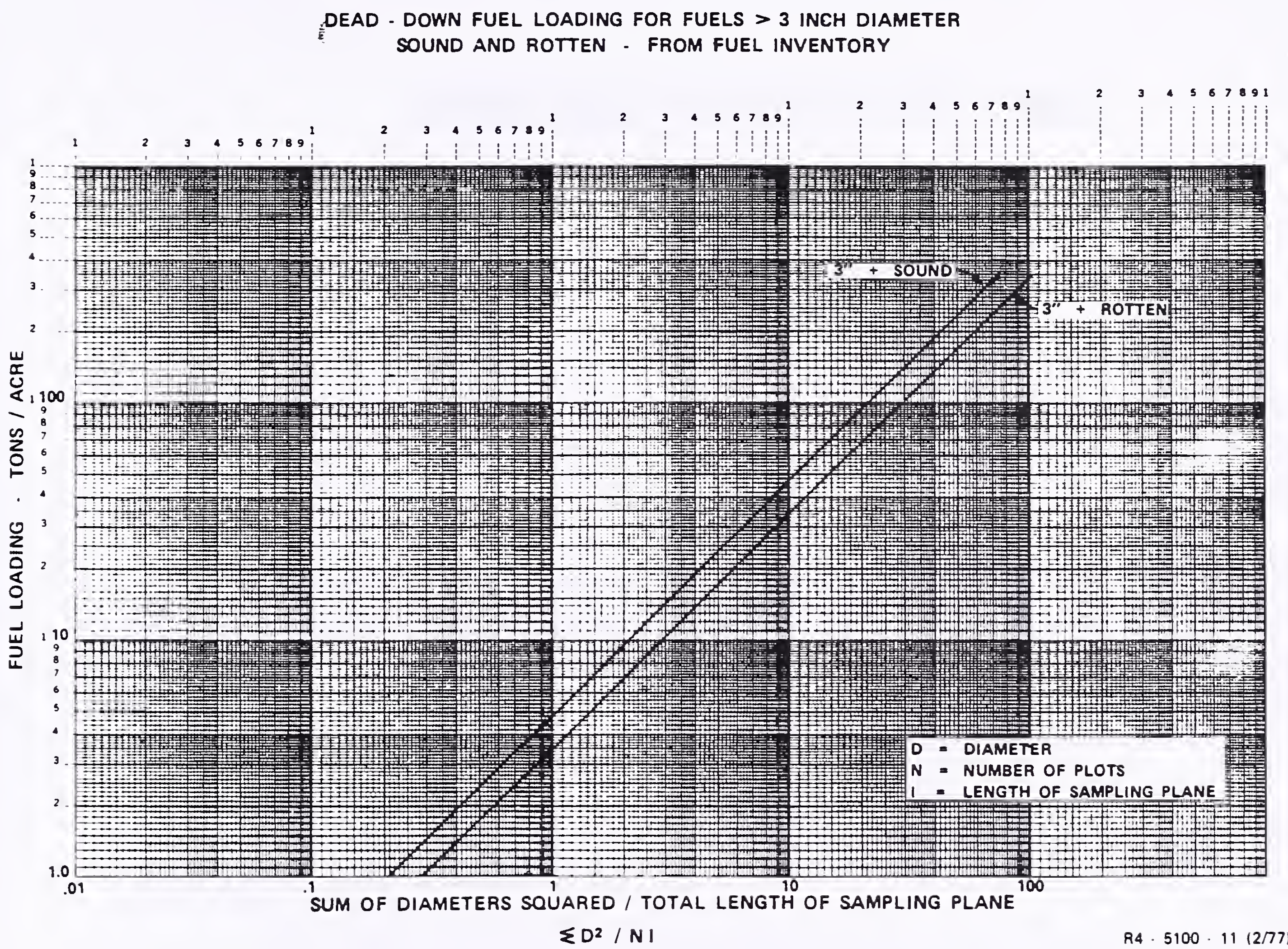


Figure 2.--Dead-down fuel load for greater than 3-inch-diameter sound and rotten wood, from diameters and transect length.

HOW THE GRAPHS ARE USED

To demonstrate the use of the graphs in figures 1 and 2, the field tally of data presented by Brown (1974) is used (fig. 3). With the data form (fig. 3) and preferably a pocket calculator available in the field, one can determine the fuel load with the graphs as follows:

1. *Size class less than 0.25 inch (0.6 cm).*--From the data sheet (fig. 3), we can see that the number of plots, N, is 2; the number of intersects (n) is 24 + 8 = 32; and the transect or sampling plane length (ℓ) is 6 ft (1.8 m). The result of $n/N\ell$, $32/(2\times6)$, is 2.67. The fuel load is found from figure 1 by entering 2.67 on the X-axis, going vertically to the line for the <0.25-inch size class, turning 90° to the left to the Y-axis where a value of about 0.28 ton per acre (0.63 ton (metric) per hectare) is read. Enter and read the values carefully because of the logarithmic scales.

2. *Size class 0.25 to 1.0 inch (2.5 cm).*--N = 2, n = 9 + 2 = 11, and ℓ = 6 ft (1.8 m). The result, $n/N\ell$, is $11/(2\times6)$ or 0.92. Proceeding as before but using the line for the 0.25- to 1.0-inch size class, the fuel load is about 1.68 tons per acre (3.8 t/ha) without any slope correction.

3. *Size class 1.0 to 3.0 inches (7.6 cm).*--N = 2, n = 3, ℓ = 10 ft (3.1 m). The result is $3/(2\times10)$ or 0.15 and the load is found to be near 2.18 tons per acre (4.9 t/ha).

4. *Size class sound 3+ inches.*--Above 3-inch diameter, the intercepts are tallied by the diameter of each piece and the squared diameters (d^2) are summed (Σ) as follows:

$$\Sigma d^2 = (10)^2 + (3)^2 + (8)^2 + (12)^2 = 100 + 9 + 64 + 144 = 317.$$

The result, $\Sigma d^2/N\ell$, is $317/(2\times35)$ or 4.53 and the fuel load is found on figure 2 to be near 21.1 tons per acre (47.3 t/ha).

5. *Size class rotten 3+ inches.*--The result, $\Sigma d^2/N\ell$, is $769/(2\times35)$ or 10.99 and the fuel load is near 38.3 tons per acre (85.9 t/ha).

The estimated total fuel load is the sum of all size classes:

0.28 + 1.68 + 2.18 + 21.1 + 38.3 = 63.5 tons per acre (142 t/ha).

FOREST		SUBCOMPARTMENT	-	ASPECT	
BLOCK		STAND		COVER TYPE	
COMPARTMENT		ELEVATION		HABITAT TYPE	

SIZE CLASS (In.) :	0 - 1	1 - 3	3+
LENGTH OF SAMPLING PLANE (Ft.) :	6	10	35

		NO. OF INTERSECTS			DUFF DEPTH		3+ DIAMETER						FUEL DEPTH		
Plot No.	Slope	0 - .25"	.25 - 1"	1 - 3"	First	Second	Sound	Sound	Sound	Rotten	Rotten	Rotten	First	Second	Third
1	3	2.4	9	3	1.1	1.7	1.0	3	8			2.5	1.0	0	3
1									1.2						
2	5	8	2	0	8	9						1.2	1.8	7	2

GROUND FUEL COMPOSITION		If heavy slash, code 1 :
Species	Percent	
1.		
2.		
3.		

Figure 3.--Sample of a field tally sheet with typical computations (after Brown 1974).

When using the graphs to estimate fuel load in size classes under 3 inches you must consider the *number of interceptions* for that size class. Categories above 3 inches must consider the *sum of the squared diameters* for the pieces intercepted. Do not try to estimate the greater than 3-inch fuel loads using figure 1 or less than 3-inch fuel loads from figure 2. Serious errors in the estimates will result. Another common source of error is to carry the same sampling plane length over from one size class to another. Always note the transcript distance used. Another source of error is incorrect entry on the logarithmic scale; always note the correct value.

Table 1.--*Sum of squared diameters for a given diameter and interceptions up to 10*

Diam-	Diam-	Σd^2 for (n) - number of pieces intercepted										
eter	eter^2	1	2	3	4	5	6	7	8	9	10	
Inches	*In^2*											
3	9	9	18	27	36	45	54	63	72	81	90	10 tons/acre
4	16	16	32	48	64	80	96	112	128	144	160	
5	25	25	50	75	100	125	150	175	200	225	250	
6	36	36	72	108	144	180	216	252	288	324	360	
7	49	49	98	147	196	245	294	343	392	441	490	50 tons/acre
8	64	64	128	192	256	320	384	448	512	576	640	
9	81	81	162	243	324	405	486	567	648	729	810	
10	100	100	200	300	400	500	600	700	800	900	1,000	
11	121	121	242	363	484	605	726	847	968	1,089	1,210	
12	144	144	288	432	576	720	864	1,008	1,152	1,296	1,440	150 tons/acre
13	169	169	338	507	676	845	1,014	1,183	1,352	1,521	1,690	
14	196	196	392	588	784	980	1,176	1,372	1,568	1,764	1,960	
15	225	225	450	675	900	1,125	1,350	1,575	1,800	2,025	2,250	
16	256	256	512	768	1,024	1,280	1,536	1,792	2,048	2,304	2,560	
17	289	289	578	867	1,156	1,445	1,734	2,023	2,312	2,601	2,890	
18	324	324	648	972	1,296	1,620	1,944	2,268	2,592	2,916	3,240	300 tons/acre
19	361	361	722	1,083	1,444	1,805	2,166	2,527	2,888	3,249		
20	400	400	800	1,200	1,600	2,000	2,400	2,800	3,200			
22	484	484	968	1,452	1,936	2,420	2,904	3,388				
24	576	576	1,152	1,728	2,304	2,880	3,456					
26	676	676	1,352	2,028	2,704	3,380						
28	784	784	1,568	2,352	3,136							
30	900	900	1,800	2,700								
35	1,225	1,225	2,450									
40	1,600	1,600	3,200									
45	2,025	2,025										
50	2,500	2,500										
60	3,600	3,600										
70	4,900	4,900										
80	6,400	6,400										
90	8,100	8,100										

It is recommended that a field form similar to figure 3 be used to collect data for each stand inventoried. To effectively use the graphs, you must have the number of intercepts (n) in each size class; the sum of the diameters squared (Σd^2) of pieces larger than 3-inch diameter; the number of plots (N) taken in the stand; and the length (ℓ) of the sampling plane used for each size class.

In many inventories, several intercepts can be made of material of the same diameter. To simplify the arithmetic, table 1 was generated to present the Σd^2 for diameters from 3 to 90 inches (7.6 to 229 cm) and interceptions from 1 to 10 pieces. The user simply has to add together the values for each diameter intercepted. For example, assume the following sound 3+ inch field data:

Diameter	*Interceptions*	*Σd^2 (from table 1)*
3	6	54
7	2	98
10	4	400
	Total	552

With the previous number of plots (N) of 2 and a transect length (ℓ) of 35 feet (10.7 m), the result of $\Sigma d^2/N\ell$ is 552/(2×35) or 7.88. The fuel load of sound 3+ inches would be 37.5 tons per acre (84.1 t/ha), from figure 2. Table 1 can be used to determine the sum of d^2 for either sound or rotten material. The lines for 10, 50, 150, and 300 tons per acre (22.4, 112, 336, and 673 t/ha) were determined for a single plot in a 50-ft (15.2-m) transect length. These lines mark off what is generally considered light, medium, and heavy loadings and may help the user to more quickly identify fuel loadings in the field.

HOW FUEL LOADING DETERMINATIONS CAN BE IMPROVED

Accuracy of graphic aids can be improved by refining the data in the calculations. The intent of the graphic aids, however, is to provide an easy and rapid way to determine fuel loads in the field. The data could be readily improved by correcting for slope and the specific gravity of the size classes. Improvements are also possible by adjusting the mean diameter of the size classes or allowing for differences in the nonhorizontal correction factor. However, these latter improvements would be best handled in the computer for analysis that requires the detail.

Slope

When fuels are sampled on a slope and the data are to be considered on a horizontal projection, a slope correction factor should be applied. It is desirable that the slope along the transect plane be noted and used for the correction. If slope was not recorded but the general slope of the site is available, a value equal to one-half the general slope should be used. This is because the sampling plane has equal opportunity to be on any slope between zero and the general slope. Once a slope has been selected, the correction factor, c, can be determined from figure 4 up to 110 percent slope. The slope correction factor is multiplied times the total fuel load, or specific size class fuel loads, as desired. If a total estimate of the fuel load is desired, the simplest approach is the single calculation using total fuel load.

On rare occasions, the transects may be located on slopes greater than 110 percent. To determine the correction factor in those cases, the equation for the correction factor can be used:

$$c = \sqrt{1 + \left[\frac{\text{Percent slope}}{100}\right]^2}. \qquad (1)$$

For the data presented in figure 4, the total fuel load was 63.5 tons per acre (142 t/ha) with no slope correction. If the assigned slope were 80 percent, the total fuel load would be multiplied by the correction factor of 1.28 (from fig. 4), 63.5 × 1.28 = 81.3 tons per acre (182 t/ha) on the flat. For slopes less than 30 percent, load determinations are low by less than 5 percent, if no correction is made.

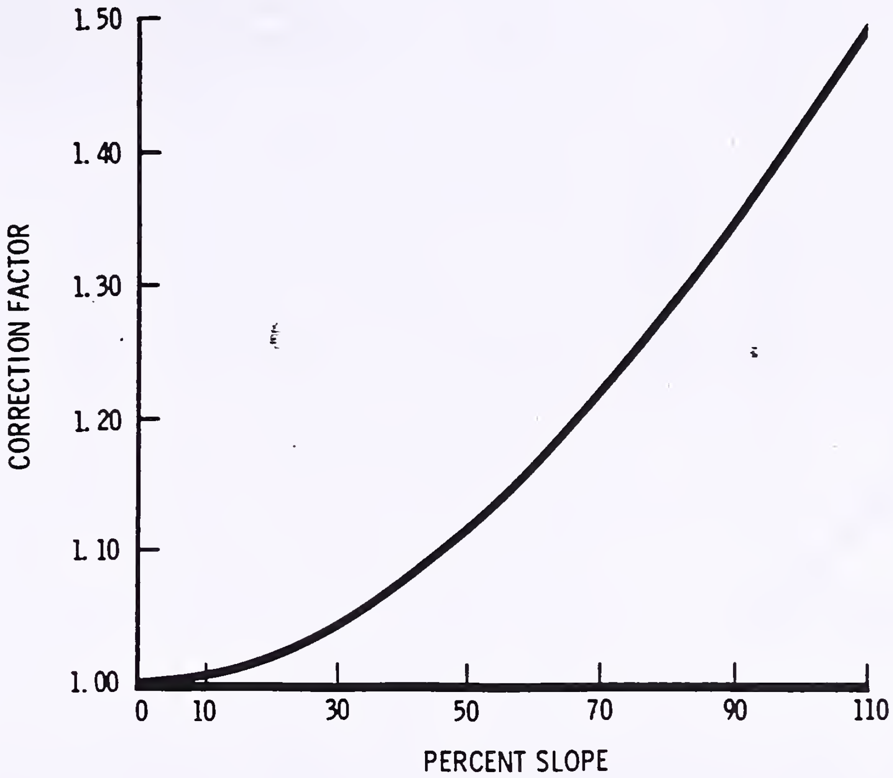


Figure 4.--Correction factor to be multiplied by fuel load to account for slope.

Specific Gravity

Estimates of fuel loads can also be improved by assigning specific gravities to each size class. If one knows the specific gravity of the timber type in which the inventory is being made, correction for specific gravity can be made using figure 5. For the less than 1.0-in (2.5-cm) diameter classes, a reference specific gravity of 0.48 is used (fig. 5). For the size classes greater than 1.0, the reference specific gravity is 0.40. This is presented by the upper line in figure 5.

Correction for each size class can be made from figure 5. The fuel load determined from figures 1 and 2 is multiplied by the correction factor. For example, if the specific gravity for all sound wood size classes is 0.6 for the example on page 4, item 5, the correction factor for less than 3-inch material is 1.25 and 1.50 for the 3-inch plus material:

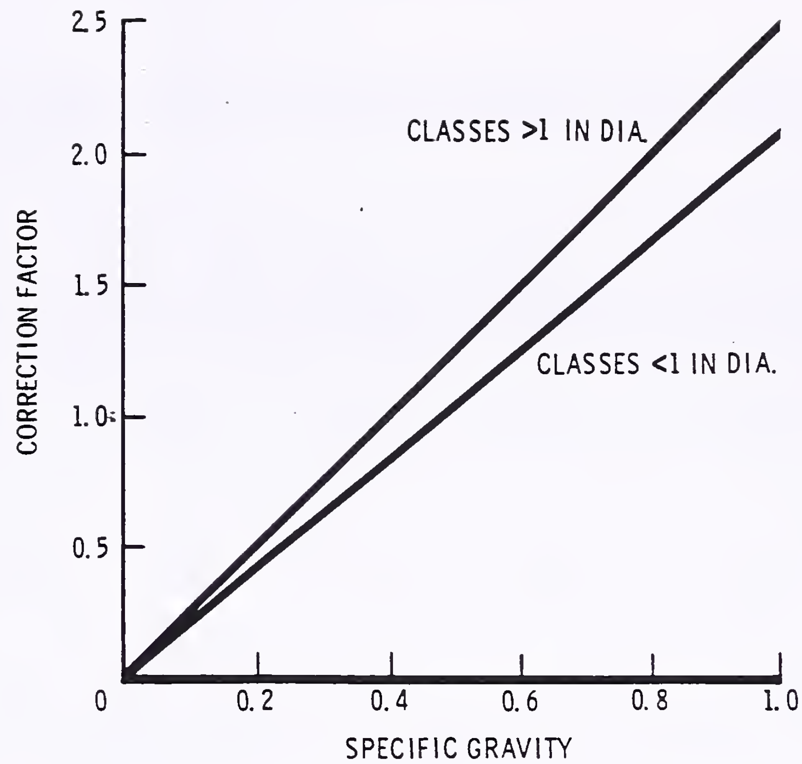
1.	<0.25-inch size class:	w = 0.28 × 1.25 =	0.35
2.	0.25- to 1.0-inch size class:	w = 1.68 × 1.25 =	2.10
3.	1.0- to 3-inch size class:	w = 2.18 × 1.50 =	3.27
4.	3+-inch sound size class:	w = 21.1 × 1.50 =	31.65
5.	3+-inch rotten size class:	w = 38.3 × 1.00 =	38.3
			75.9 tons/acre (170 t/ha).

The previous no-slope total load was 63.5 (142 t/ha), so the change in specific gravity increased the original load determination by 19 percent.

Wood Handbook No. 72 rev. (U.S. Forest Products Laboratory 1974) gives the specific gravity for the various woods of the United States at 12 percent moisture content. For softwoods, the range in specific gravity is from 0.31 to 0.59 with an average of about 0.43. This agrees closely with the reference specific gravities used to estimate fuel loads. For hardwoods, the range is from 0.34 to 0.88 with an average of about 0.57.

A table of specific gravities was developed from analysis of the 37 major forest types described in the U.S. Department of Agriculture, Forest Service Handbook No. 445 on Silvicultural Systems (1973). The specific gravities of the greater than 3-inch

Figure 5.--Graphic determination of correction factor to adjust fuel loads for variations in specific gravity.



material was taken from the Wood Handbook (U.S. Forest Products Laboratory 1974) and an average specific gravity calculated using the major timber types listed for each forest type. Two major groups were apparent: (1) forest types of the Rocky Mountains and westward; and (2) forest types east of the Rockies. This second group can be divided into two subgroups: (2a) Northern and northeastern forest types; and (2b) southern and southeastern forest types. The average specific gravities determined for the size classes by group are shown in table 2.

Rather than do extensive adjustment in the field, it is recommended that specific changes be made for computer processing. For field use, the adjustments should be minimized so estimates can be made quickly and provide reasonable answers. Use of figures 1 and 2 without correction for specific gravity may introduce a 20 percent error. This should be acceptable for field uses other than fuel management, in which case estimates should be processed by computer for maximum accuracy.

Mean Diameter Per Size Class

Adjustments to mean diameter of the size classes less than 3 inches should be done for the computer processing rather than field use. However, if one uses equations (2) through (6) in the appendix A (page 12) on a hand calculator and wants to change the mean diameter, he would have to go back to equation (1). The new diameter per size class would be used to establish new coefficients for the species of interest (Brown 1974; Brown and Roussopoulos 1974) in equations (2), (3), and (4). This seems to be imposing more precision than the estimate merits, but is possible if the user desires.

SUMMARY

This publication is intended to adapt for field use procedures described in *Handbook For Inventorying Downed Woody Materials* (Brown 1974). Accuracy of fuel estimates can be improved by individual measurements and use of specific data for a timber type. Tearout graphs are included in appendix B. The tearouts should be covered with plastic to extend their useful life.

Table 2.--*Specific gravities of fuel size classes by geographic sections of continental United States*

Forest group	Size classes (inches)				
	0.25	0.25-1.0	1.0-3.0	3+ sound	3+ rotten
Rocky Mountains westward	0.48	0.48	0.40	0.40	0.30
East of Rocky Mountains-Northern and Northeast types	.60	.60	.50	.50	.30
Southern and Southeast types	.70	.70	.58	.58	.30

PUBLICATIONS CITED

Beaufait, William R., Michael A. Marsden, and Rodney A. Norum.
1974. Inventory of slash fuels using 3P subsampling. USDA For. Serv. Gen. Tech. Rep. INT-13, 17 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K.
1971. A planar intersect method for sampling fuel volume and surface area. For. Sci. 17(1):96-102.

Brown, James K.
1974. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. INT-16, 24 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K., and Peter J. Roussopoulos.
1974. Eliminating biases in the planar intersect method for estimating volumes of small fuels. For. Sci. 20(4):350-356.

Morris, William G.
1970. Photo inventory of fine logging slash. Photogramm. Eng., J. Am. Soc. Photogramm. XXXVI(12):1252-1256.

Muraro, S. J.
1970. Slash fuel inventories from 60-mm low-level photography. Can. For. Serv., Dep. Fish. and For., 12 p. Queen's Printer for Canada, Ottawa, Ontario (Cat. Fo. 47 - 1268).

Roussopoulos, Peter J., and Von J. Johnson.
1973. Estimating slash fuel loading for several Lake States tree species. USDA For. Serv. Res. Pap. NC-88, 8 p. North Central For. Exp. Stn., St. Paul, Minn.

U.S. Department of Agriculture, Forest Service.
1973. Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric. Handb. 445, 124 p. Gov. Print. Off., Washington, D.C.

U.S. Forest Products Laboratory.
1974. Wood handbook: wood as an engineering material. USDA Agric. Handb. 72, rev., 414 p. Sup. Doc., U.S. Gov. Print. Off., Washington, D.C.

Van Wagner, C. E.
1968. The line intersect method in forest fuel sampling. For. Sci. 14:20-26.

APPENDIX A

How the Graphs Were Developed

The planar intersect method for estimating the quantity of fuel by size class is described elsewhere (Van Wagner 1968; Brown 1971; Brown and Roussopoulos 1974) and will not be discussed here. It is assumed the data-taking procedures are understood and it is desired to convert that data to estimates of fuel quantity. Other methods of estimating slash fuel loadings have been investigated or developed (Morris 1970; Muraro 1970; Roussopoulos and Johnson 1973; Beaufait and others 1974). Brown (1974) noted that some of these methods may be more efficient to use in particular cases and should be used where applicable. However, use of the simple field procedures given in Brown's Handbook and use of these graphic aids can provide a quick, objective field assessment of fuel quantity. The information in figures 1 and 2 was developed from an equation presented by Brown and Roussopoulos (1974), equation (2).

The basic equation used for the graphs of fuel loads is:

$$w = (11.64) \left(\frac{\Sigma d^2}{N\ell}\right) \; s \cdot \alpha \cdot c, \text{ tons/acre} \qquad (1)$$

where

(11.64) = conversion of volume to tons per acre
Σd^2 = sum of squared diameters for interceptions of pieces greater than 3-inch diameter, in^2
or = nd^2 for interceptions of pieces less than 3-inch diameter, in^2
n = number of interceptions
d = diameter of piece intercepted or the quadratic mean diameter of the size class less than 3-inch diameter, inches
N = number of plots taken
ℓ = length of the sampling plane in each plot, ft
s = specific gravity of fuels
α = correction factor for nonhorizontal angle of fuel elements
c = correction factor for slope.

Assumptions were made for each size class and specific equations established for estimating fuel load.

1. For the size classes less than 3-inch diameter, the composite mean quadratic diameters determined by Brown (1974) were used:

<0.25 inch, $d = 0.123$ inch (0.312 cm), $d^2 = 0.0151$ in^2
0.25 - 1.0 inch, $d = 0.538$ inch (1.37 cm), $d^2 = 0.289$ in^2
1.0 - 3.0 inches, $d = 1.661$ inches (4.22 cm), $d^2 = 2.76$ in^2.

These are assumed typical for all western conifers.

2. The specific gravities used were established by Brown (1974) for western conifers:

<0.25 inch, s = 0.48
0.25 - 1.0 inch, s = 0.48
1.0 - 3.0 inches, s = 0.40
Sound 3+ inches, s = 0.40
Rotten 3+ inches, s = 0.30.

3. Correction factors for the nonhorizontal angles of fuel particles were based upon the work of Brown (1974) and Brown and Roussopoulos (1974). Slash was found to have slightly higher factors than naturally fallen material. Ponderosa pine slash had the highest correction factors but for general use the following factors were used:

<3.0 inches, $\propto$ = 1.13
3+ inches, $\propto$ = 1.0.

The fuel particles greater than 3 inches in diameter are mostly bole material and large branchwood that, due to gravity, will tend to become positioned parallel to the ground.

4. No correction for slope was included, assuming that the sampling plane was on a nearly level surface. The correction factor then is 1.0. The error in load is less than +4 percent when the slope is 30 percent or less.

The equations used to develop the graphs expand from equation (1) to the following:

<0.25 inch

$$w = 0.09533\ n/(N\ell)\ \text{tons/acre} \tag{2}$$

0.25 to 1.0 inch

$$w = 1.825\ n/(N\ell)\ \text{tons/acre} \tag{3}$$

1.0 to 3.0 inches

$$w = 14.52\ n/(N\ell)\ \text{tons/acre} \tag{4}$$

Sound 3+ inches

$$w = 4.656\ \Sigma d^2/(N\ell)\ \text{tons/acre} \tag{5}$$

Rotten 3+ inches

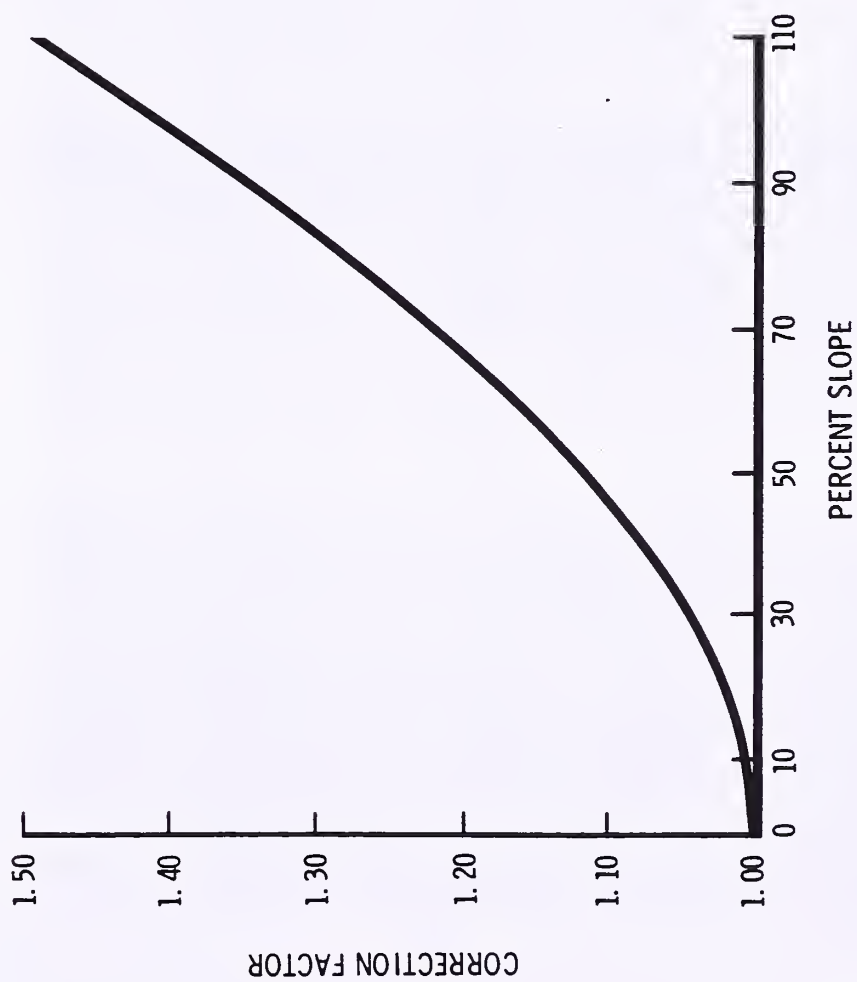
$$w = 3.492\ \Sigma d^2/(N\ell)\ \text{tons/acre} \tag{6}$$

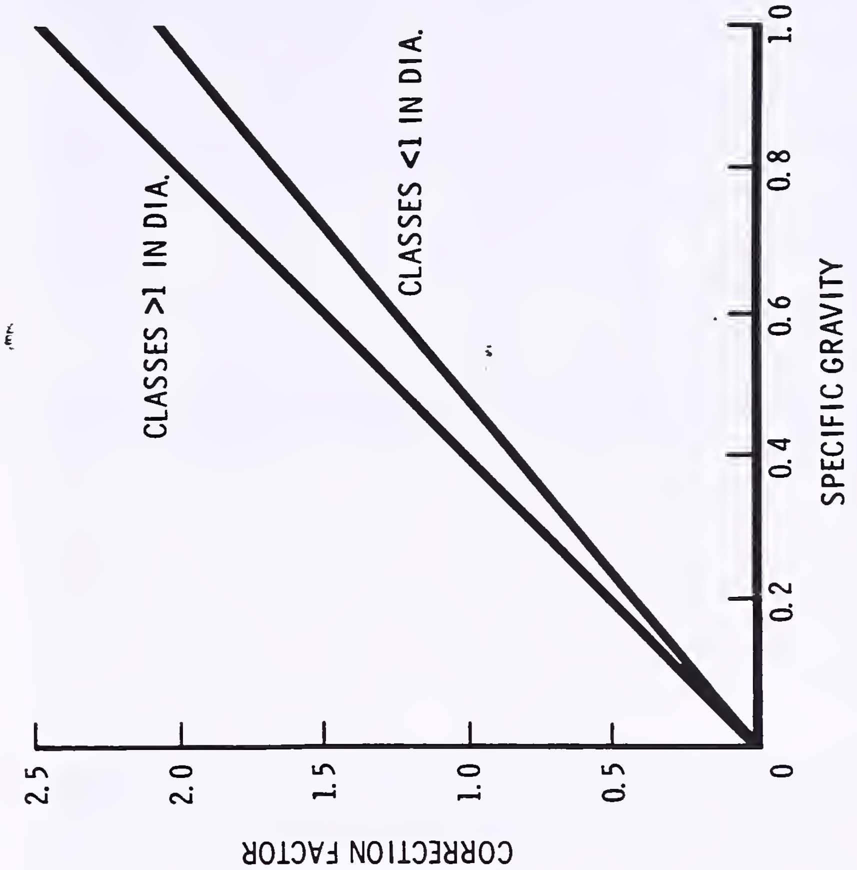
APPENDIX B

Tearouts for Computing Fuel Load, Corrections for Slope and Specific Gravity

Table 1.--*Sum of squared diameters for a given diameter and interceptions up to 10*

Diameter	Diameter²	Σd^2 for (n) - number of pieces intercepted: 1	2	3	4	5	6	7	8	9	10	
Inches	*In²*											
3	9	9	18	27	36	45	54	63	72	81	90	
4	16	16	32	48	64	80	96	112	128	144	160	10 tons/acre
5	25	25	50	75	100	125	150	175	200	225	250	
6	36	36	72	108	144	180	216	252	288	324	360	
7	49	49	98	147	196	245	294	343	392	441	490	
8	64	64	128	192	256	320	384	448	512	576	640	50 tons/acre
9	81	81	162	243	324	405	486	567	648	729	810	
10	100	100	200	300	400	500	600	700	800	900	1,000	
11	121	121	242	363	484	605	726	847	968	1,089	1,210	
12	144	144	288	432	576	720	864	1,008	1,152	1,296	1,440	
13	169	169	338	507	676	845	1,014	1,183	1,352	1,521	1,690	150 tons/acre
14	196	196	392	588	784	980	1,176	1,372	1,568	1,764	1,960	
15	225	225	450	675	900	1,125	1,350	1,575	1,800	2,025	2,250	
16	256	256	512	768	1,024	1,280	1,536	1,792	2,048	2,304	2,560	
17	289	289	578	867	1,156	1,445	1,734	2,023	2,312	2,601	2,890	
18	324	324	648	972	1,296	1,620	1,944	2,268	2,592	2,916	3,240	
19	361	361	722	1,083	1,444	1,805	2,166	2,527	2,888	3,249		300 tons/acre
20	400	400	800	1,200	1,600	2,000	2,400	2,800	3,200			
22	484	484	968	1,452	1,936	2,420	2,904	3,388				
24	576	576	1,152	1,728	2,304	2,880	3,456					
26	676	676	1,352	2,028	2,704	3,380						
28	784	784	1,568	2,352	3,136							
30	900	900	1,800	2,700								
35	1,225	1,225	2,450									
40	1,600	1,600	3,200									
45	2,025	2,025										
50	2,500	2,500										
60	3,600	3,600										
70	4,900	4,900										
80	6,400	6,400										
90	8,100	8,100										





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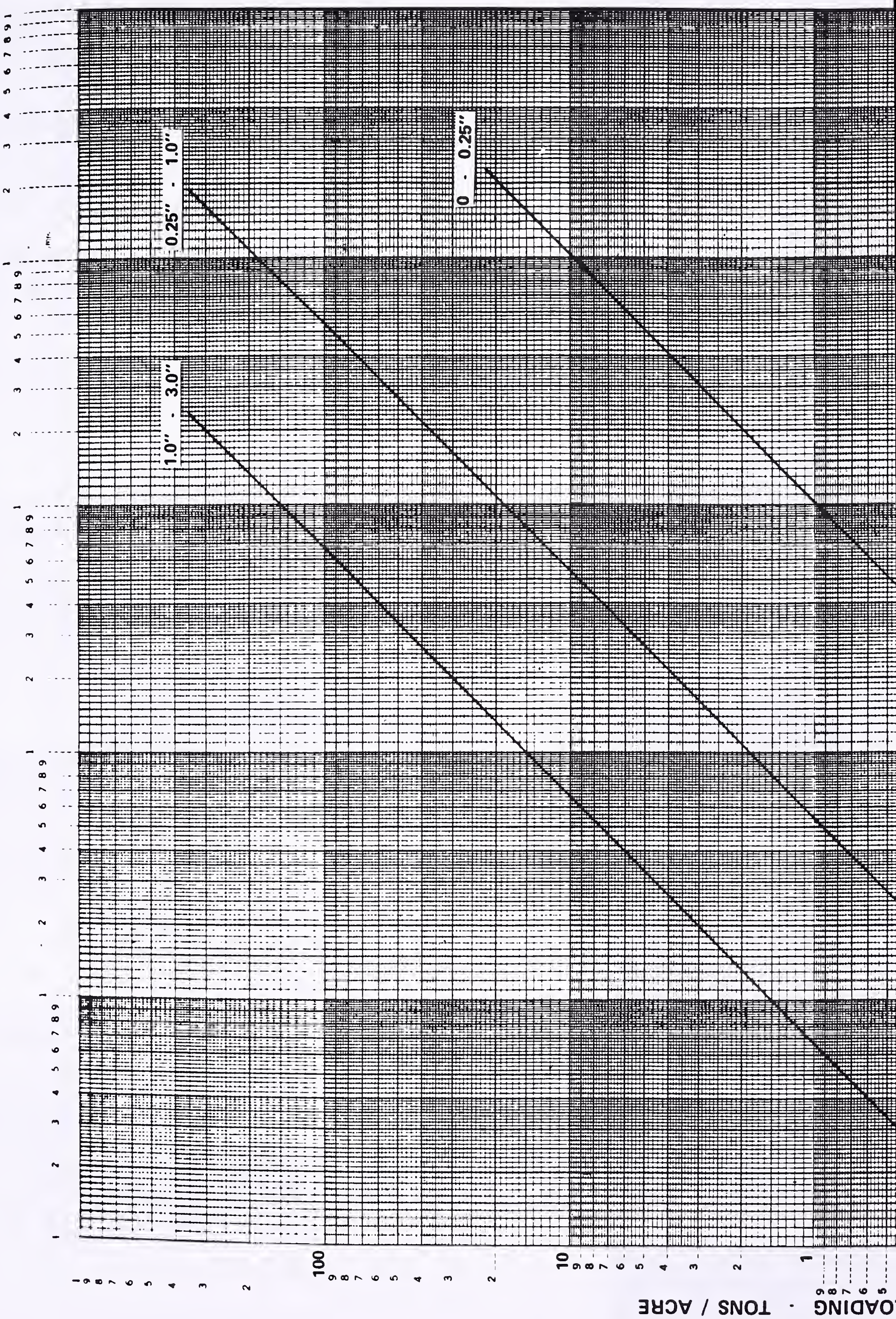
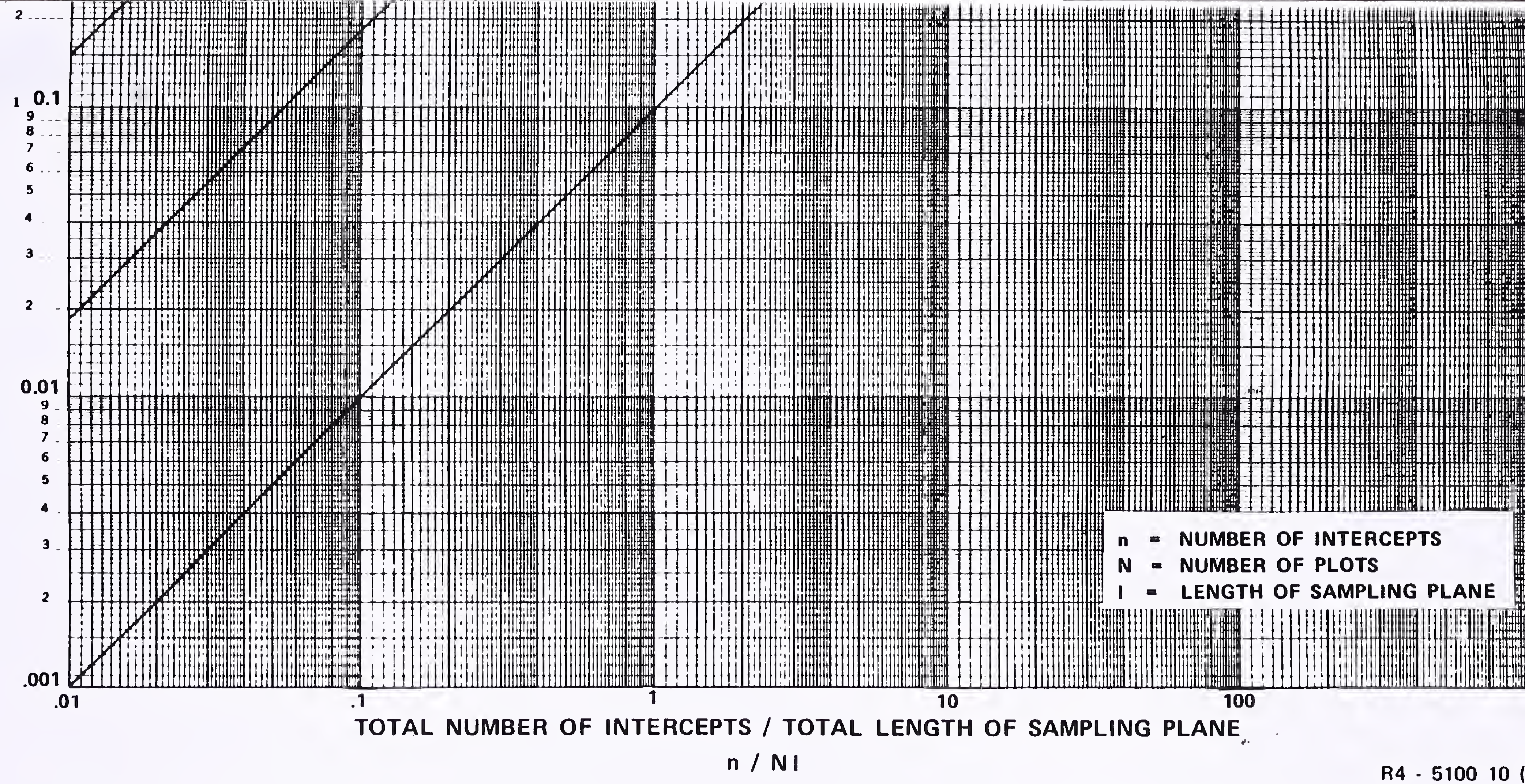
DEAD DOWN FUEL LOADING FOR 0 - 3 INCH FUELS FROM FUEL INVENTORY





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Anderson, Hal E.
1978. Graphic aids for field calculation of dead, down forest fuels. USDA For. Serv. Gen. Tech. Rep. INT-45, 21 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Provides graphic aids to facilitate calculation of fuel loads from planar intersect sampling desired in "Handbook for Inventorying Downed Woody Material" (Brown 1974). Includes graphs for increasing accuracy by correcting slope and specific gravity.

KEYWORDS: fuel inventory, biomass, simulation, modeling.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

- Billings, Montana
- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)